Universidade Federal de Juiz de Fora
Instituto de Ciências Exatas
Bacharelado em Ciência da Computação

Improving Learning Material Repositories Using Student Profiles

Versão completa através de:
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JUIZ DE FORA
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MONOGRAFIA SUBMETIDA AO CORPO DOCENTE DO INSTITUTO DE CIÊNCIAS EXATAS DA UNIVERSIDADE FEDERAL DE JUIZ DE FORA, COMO PARTE INTEGRANTE DOS REQUISITOS NECESSÁRIOS PARA A OBTENÇÃO DO GRAU DE BACHAREL EM CIÊNCIA DA COMPUTAÇÃO.

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12 DE MARÇO, 2021

À minha namorada e irmão.

Aos pais, pelo apoio e sustento.

Resumo

A geração de Sequências Curriculares Adaptativas (SCAs) compreende uma abordagem presente no campo da aprendizagem adaptativa, que visa orientar o aluno a seguir o melhor caminho de aprendizagem, de forma a maximizar a compreensão e a eficiência na aprendizagem. Essa abordagem, baseada nos dados dos alunos e no repositório de materiais didáticos, equivale a gerar uma sequência de materiais para cada aluno, a qual é adaptada aos seus objetivos e peculiaridades. Porém, apesar dos benefícios, alguns problemas podem ser destacados, como a restrição dos alunos aos materiais do repositório e a dificuldade em conhecer as lacunas que precisam ser preenchidas no repositório para que ele possa atender melhor os alunos. Portanto, este trabalho se propõe, além de atender aos objetivos traçados com a geração de SCAs, auxiliar os gestores de repositórios de materiais educacionais a conhecer suas necessidades. Para tanto, propõe-se a utilização de abordagens de otimização, como GRASP e Simulated Annealing, para gerar novas possibilidades de materiais que podem melhorar a recomendação feita pelo SCA, auxiliar os professores na montagem destes e consequentemente melhorar a satisfação do aluno. Os resultados obtidos são promisores e indicam que a utilização do GRASP para a escolha dos conceitos cobertos pelos materiais e força bruta para as outras características com menos opções de escolha conseguem gerar bons direcionamentos na criação dos materiais. O texto completo está em sigilo e pode ser requisitado através de: coord.computacao@ice.ufjf.br

Palavras-chave: Repositório de Objetos de Aprendizagem, Repositórios de Materiais Didáticos, Sequências Curriculares Adaptativas, Perfil dos Alunos.

Abstract

The generation of Adaptive Curriculum Sequences (ACS) comprises an approach present in adaptive learning field, which aims to guide the student to follow the best learning path, to maximize understanding and efficiency in learning. This approach, based on data from students and on the repository of learning materials, amount to generating a sequence of materials for each student, which is adapted to the objectives and peculiarities of the same. However, despite the benefits, some problems can be highlighted in this approach, such as the restriction of students to materials in the repository and the difficulty in knowing the gaps that need to be filled in the repository so that it can better serve students. Therefore, this work proposes to, besides satisfying the objectives addressed with the ACS, assist managers of educational material repositories to know their needs. To this end, it is proposed the use of optimization approaches, such as GRASP and Simulated Annealing, to generate new material possibilities that can improve the recommendations made by the ACS, assist teachers in assembling them, and consequently improve student satisfaction. The results obtained are promising and indicate that the use of GRASP to choose the concepts covered by the materials and brute force for the other characteristics with fewer options to choose, can generate good directions in the creation of the materials. The full text is confidential and may be requested through: coord.computacao@ice.ufjf.br

Keywords: Learning Objects Repository, Learning Materials Repository, Repository of Learning Objects, Adaptive Curriculum Sequencing, Student Profiles

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"All things change in a dynamic environment. Your effort to remain what you are is what limits you".

Ghost In The Shell (Puppet master)

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DCC	Departamento de Ciência da Computução
UFJF	Universidade Federal de Juiz de Fora
ACS	Adaptive Curricular Sequence
VLE	Virtual Learning Environments
GRASP	Greedy Randomized Adaptive Search Procedure
SA	Simulated Annealing
FSLSM	Felder-Siverman Learning Style Model

1 Expanded abstract

Online courses, mainly those placed in official Virtual Learning Environments (VLE's), have been facing an increase in demand in the latest years. That phenomenon occurs, due to the VLE's advantages in face of classroom courses, such as its flexible schedule, affordable price ranges and broad accessibility (MACHADO et al., 2018) and the outburst of the Sars-Cov-2 (COVID-19).

Despite these benefits, the approach is still incipient. As online education progresses, we still face a series of obstacles which are difficult to overcome, such as the high dropout rate of students due to their lack of motivation to remain engaged with the online courses (ARAÚJO; OLIVEIRA; MARCHISOTTI, 2016), their hardenship to plan and structure their study times, and the increasingly complex preparation of teaching materials (FOJTÍK, 2018).

In terms of seeking to solve at least a few of the aforementioned issues, several authors have proposed applying adaptive learning solutions (MACHADO; BARRÉRE; SOUZA, 2018; GRUBIŠIĆ; STANKOV; ŽITKO, 2015), such as Adaptive Curriculum Sequence (ACS)[1] approach, since they consider that each student is a unique individual, and aim to offer them a better learning experience. The ACS approach (MACHADO et al., 2021) allows the choosing of teaching materials to go beyond simple recommendations, including the selection, and organization of contents.

The use of ACS has several benefits, for instance: an increase in student satisfaction and performance, reduction of the time taken to select materials, and greater exploration of the repository materials used to endow the courses. However, some problems can still be pointed out, such as the restriction on the versatility that a pre-set repository can impose materials with characteristics that are not entirely following the student model and the difficulty of the repository manager to understand what are the concerning needs of content and materials.

Given this scenario, the objective of this work is to increase the quality of learning

[1]The term ACS is used to define the problem of searching for the best learning path for a student.

object repositories by assisting its content managers by generating new configurations of useful materials for students. To achieve the aforementioned objective, the student's characteristics, the metadata of the learning materials of the analyzed repository, ACSs obtained from it and an optimization approach were used.

1.1 Proposal

The objective of this work is to use computational intelligence techniques to identify possible improvements that can be applied to educational repositories. To limit the number of new materials to be created, the method developed is restricted to only adapting the educational repository to the needs of a predefined set of student profiles. The Felder-Siverman Learning Style Model (FSLSM) (FELDER; SILVERMAN et al., 1988) model, student's available time and knowledge level for each available concept were considered for the student profiles.

There are numerous ways to assess the quality of a materials sequence for a student. Characteristics such as duration, difficulty, and subjects covered are commonly used to determine whether the selected materials meet students' needs. As the final goal of the ACS is to find sequences of materials that are appropriate to the characteristics of the students, one of the ways to improve a repository is to add materials that allow better sequences to be found.

In this way, this work makes use of a curriculum sequencing technique to find the sequence of materials most suitable for a student. From the results obtained, changes are made to the attributes in the materials repository so that the sequences found can better assist students and lead to a defined set of new materials that need to be created.

1.2 Problem definition

As input to the proposed problem, the following information was used. The student's attributes, namely, knowledge level, available time, learning style, learning goal, and the recommended sequence. The learning materials characteristics taken into account were difficulty, duration time, covered concepts, type, and the material trend towards one of

Tabela 1.1: Objectives functions and descriptions.

ID	Name	Description
O_1	concept coverage	it considers whether the materials teach concepts that the student wants to learn.
O_2	students ability	it considers whether the difficulty of the materials is consistent with the student's ability.
O_3	expected course duration	it determines whether the selected set of materials is within the student's time availability.
O_4	materials balancing	it assess whether the number of materials covering each concept is well distributed.
O_5	student's preference	it considers whether the selected materials fit the way the student learns more easily.

the options for each dimension of the FSLSM, which was defined with the relation between the IEEE-LOM attributes and the FSLSM (MACHADO et al., 2018).

In (MARTINS; MACHADO, 2020; MACHADO; BARRÉRE; SOUZA, 2019), it is used a set of five objectives that need to be optimized. These objectives are described in Table 1.1 (MACHADO et al., 2018).

The SCA literature uses a multi-objective approach, despite that, in this work, this does not happen, since the proposal is to find the best values for each characteristic of potential new material, some objectives are considered alone. The material features are difficulty level, expected learning time (duration), preference indicative (learning style), and covered concepts. Is noticeable that almost all characteristics are contemplated by the objectives independently, except for the covered concepts, which are related to two objectives.

For this manner, two subproblems were defined: (i) to generate a new concept matrix, which indicates the concepts that are covered for each material, and (ii) to generate new characteristics of the materials.

1.2.1 New concept matrix

The objectives O_1 and O_4 are considered together here, as they are related to the concepts covered by each material. Where $\mathbf{a} = A_{m\times c}$ is a binary matrix of sizes $m = |M|$ which is the number of learning materials and $c = |C|$ which is the total number of concepts that can be covered by a material.

Note that, unlike the ACS problem, here the objective is to obtain a new matrix $A'_{m\times c}$ which changes the initial concept coverage. To assess the quality of this new concept coverage matrix, the objectives O_1 and O_4 are used to determine whether changes in materials are capable of improving the results of a given student.

1.2.2 New materials' characteristics

This section presents the selection of characteristics problem. The material features contemplate here are difficulty level, expected learning time, called here by duration, and the learning style it suppose to cover. This subproblem takes part after the definition of the new concept matrix, which concerns the material concept coverage feature.

The possible values for each characteristics were defined and to check the best option, the objectives O_2, O_3, and O_4 are used for the characteristics of duration, difficulty, and LS, respectively.

1.3 Methods

This section presents methods for the subproblems presented in Section 1.2.1 and 1.2.2. Regarding the new concept matrix problem, considering the size of the search space ($2^{m\times c}$), exhaustively search is an impracticable task. Therefore, in this work, the Greedy Randomized Adaptive Search Procedure (GRASP) and Simulated Annealing (SA) metaheuristics are used. For the new materials' characteristics problem, the Brute Force Search algorithm is used. The objective of all approaches is to minimize the value of the fitness functions in Table 1.1.

1.4 Computational Experiments

With the pretext of validating the proposed approach, it was used a Learning Object Repository from a real online learning course[2] and generated adaptive sequences for 24 student profiles, exploring the different characteristics combinations. In order to have a good performance with the metaheuristic, the correct parameters needs to be settle. Thereunto, the parameters have been optimized using the irace package (LÓPEZ-IBÁÑEZ et al., 2016).

1.4.1 Results and Discussion

From the pedagogical point of view, it can assist the instructional designers, teachers and instructors in the development of learning resources by giving some fundamental points that need to be addressed by the resource to accomplish the teaching goal, that is, make students truly understand what was taught.

From the computational experiment results, it was possible to notice that the use of simple computational solutions shows a large potential in something that can have a big help in the life, job, and learning of the students and teachers. The GRASP algorithm achieve better results in all aspects that we have evaluated here. Both O_1 and O_4 objectives had better values with GRASP, which means that a relatively simple implementation algorithm with few computational resources can find good indications of concept coverage by materials.

Regardless of the features of the materials, was possible to see a pattern between the found difficulty and the student's skill level. The materials trend towards Learning Style shows that the student Group 2 despite not having so many materials created, all tend to the same LS, whereas Group 1 has more materials created, but the LS does not fully align with the last dimension. The expected learning time (duration) indicates that even if some students have more time available, the material chosen is always the one with the shortest duration. However, in some cases it is not possible to guarantee that the material meets this, and it does not mean that it is the best for learning.

[2]https://github.com/ufjf-dcc/LAPIC3-benchmark/tree/master/RealExperiments

1.5 Conclusion

In this work, a method was developed to optimize a repository and ease the search for good sequences by facilitating the teacher experience in the development of new materials. The proposed solution is meant to be used after the ACS solution to provide advantages for both instructor and student. It explores the potential of the ACS problem with some additional simple computational solutions as discussed in Section 1.4.1.

The results show greater potential in helping with the life and job of teachers by assisting them in the content development role with fundamental points that need to be addressed by the material to accomplish the teaching goal. The contributions of this work are threefold: (i) the use of metaheuristic approaches to identify gaps in material repositories in order to improve curricular sequences; (ii) an assessment of the approach with data from a real course; (iii) the availability of data and codes produced by the project in order to further research[3].

[3] https://github.com/BravoNatalie/improving-LOR

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